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# (54) LOAD CONTROL SYSTEM FOR MOTOR

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(52) **U.S. Cl.** ..... **388/811**; 318/254; 318/471; 701/36

(58) **Field of Search** ..... 318/254, 471; 361/23–34; 388/903, 934, 811; 701/36

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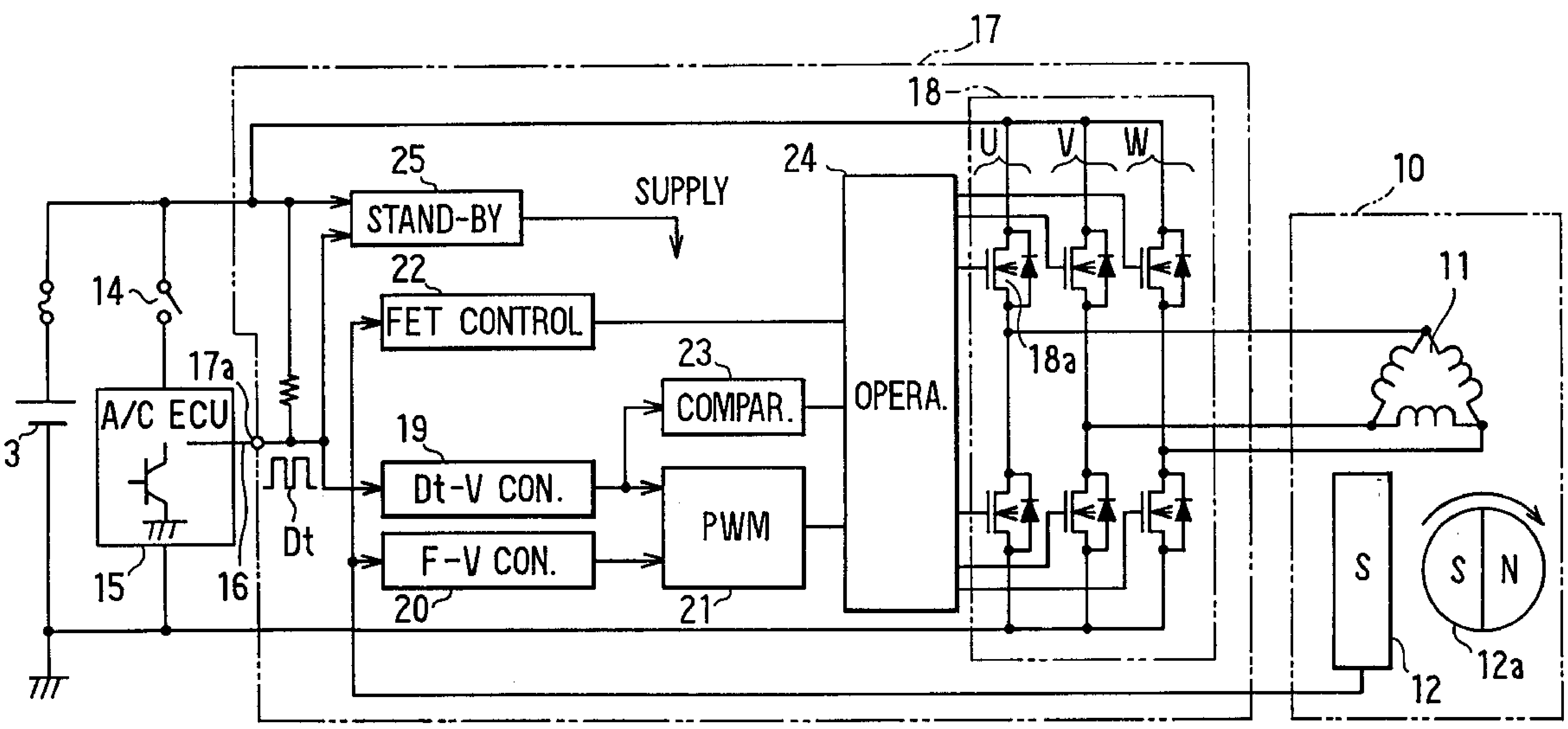
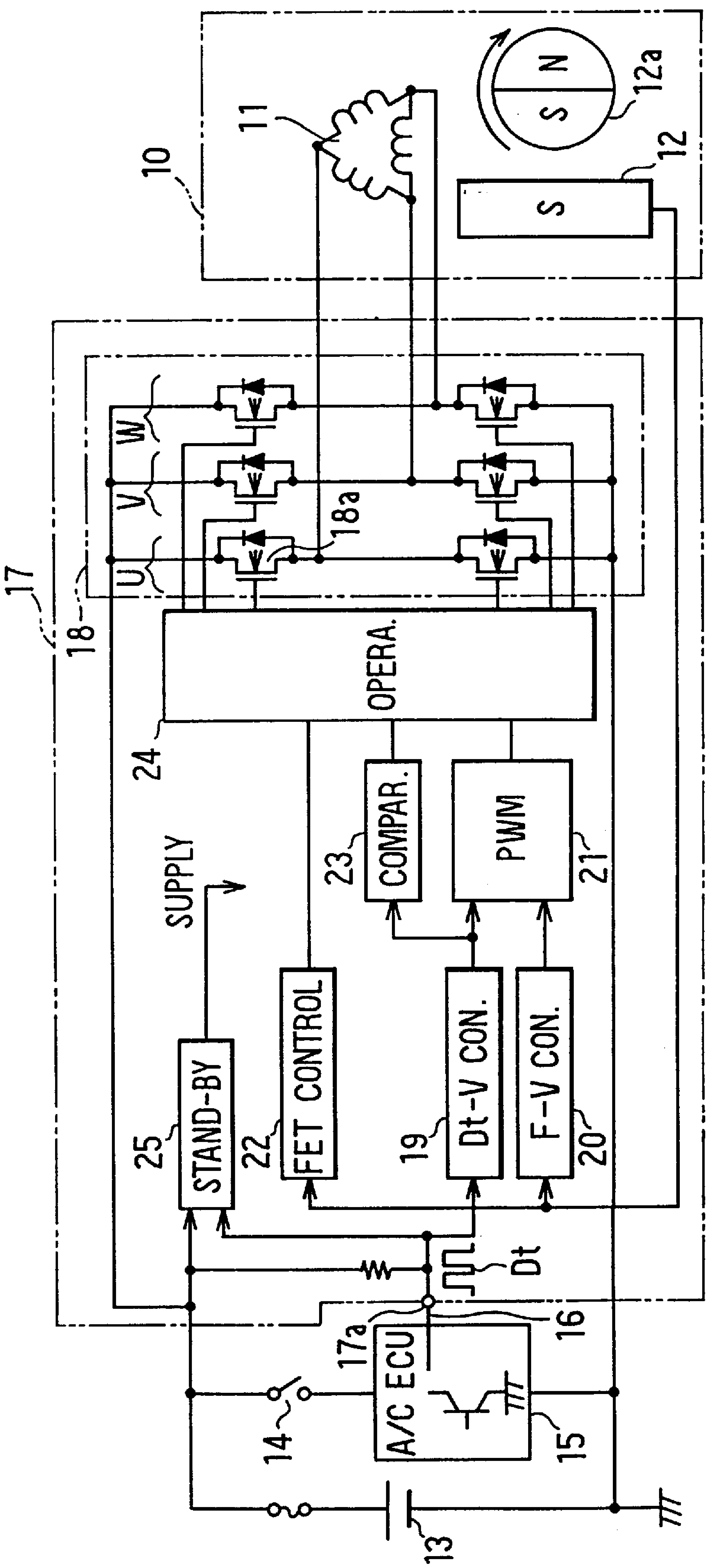
## (57) ABSTRACT

A load control system includes a driving circuit for electrically controlling a blower motor, and a control circuit for generating a control signal for the motor. The driving circuit is directly connected to an electrical power source, and the control signal from the control circuit is input into the driving circuit through a signal input line. The control signal from the control circuit is a duty signal in which a duty ratio becomes 100% when the signal input line is ground short-circuited. In the load control system, a comparison circuit determines a ground short-circuited state of the signal input line when the duty ratio is increased to a value proximate to 100%, and the motor is automatically stopped based on output from the comparison circuit when the signal input line is ground short-circuited. Thus, the load control system can prevent full-load operation of the motor due to the ground short-circuit of the signal input line, even the driving circuit is directly connected to the electrical power source.

**5 Claims, 4 Drawing Sheets**





10
11
12a
N
S
12
S
17
18
18a
U
V
W
OPERA.
24
COMPAR.
23
PWM
21
SUPPLY
STAND-BY
25
FET CONTROL
22
Dt-V CON.
19
F-V CON.
20
Dt
16
17a
A/C ECU
14
15
13


FIG. 1

FIG. 2

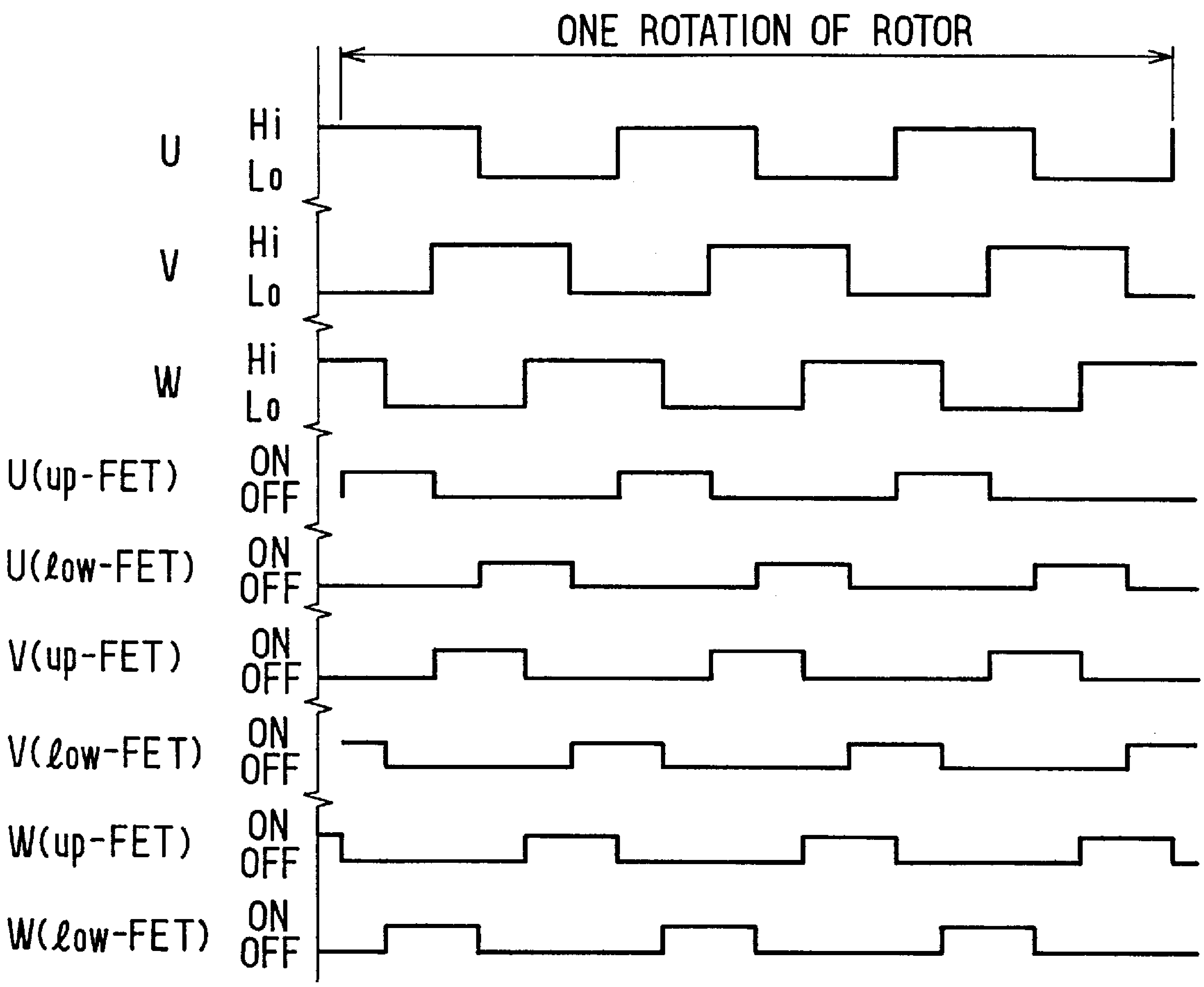

ONE ROTATION OF ROTOR
U
Hi
Lo
V
Hi
Lo
W
Hi
Lo
U(up-FET)
ON
OFF
U(ℓow-FET)
ON
OFF
V(up-FET)
ON
OFF
V(ℓow-FET)
ON
OFF
W(up-FET)
ON
OFF
W(ℓow-FET)
ON
OFF

FIG. 3

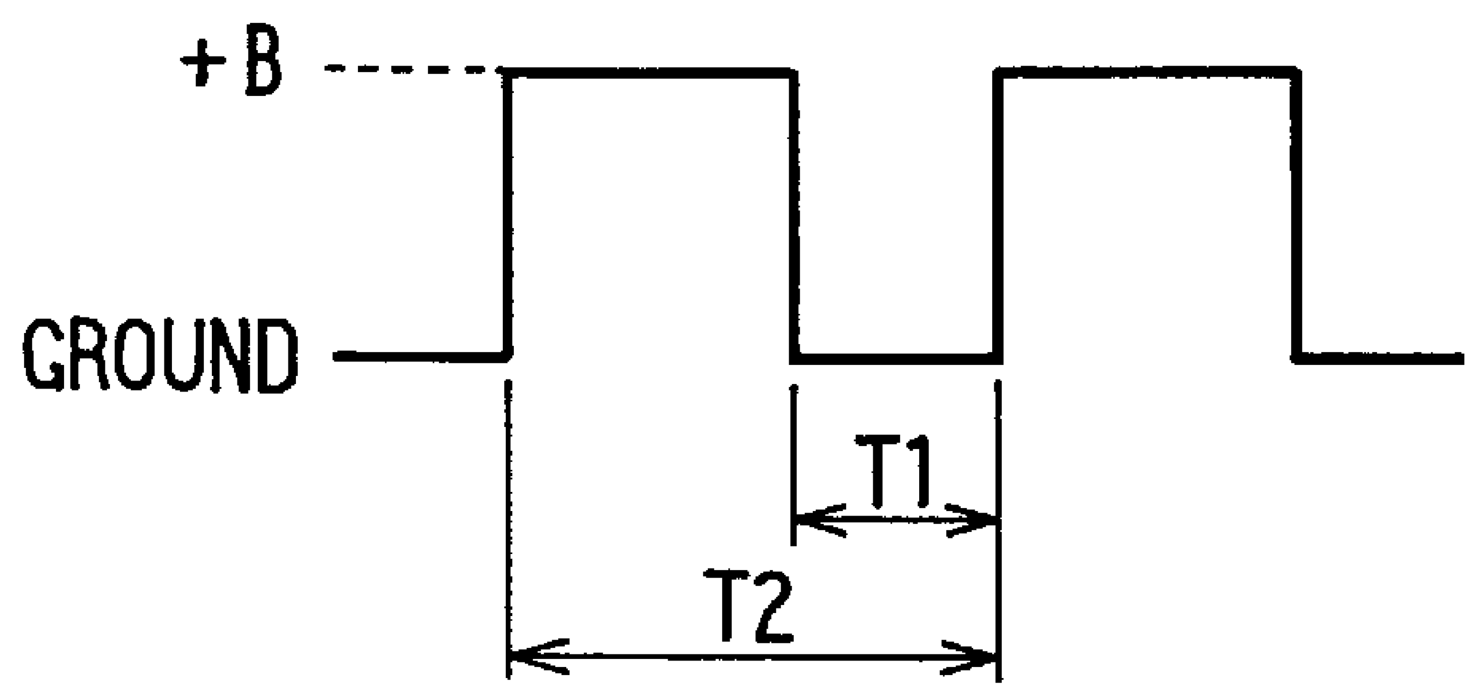

+B
GROUND
T1
T2

FIG. 4

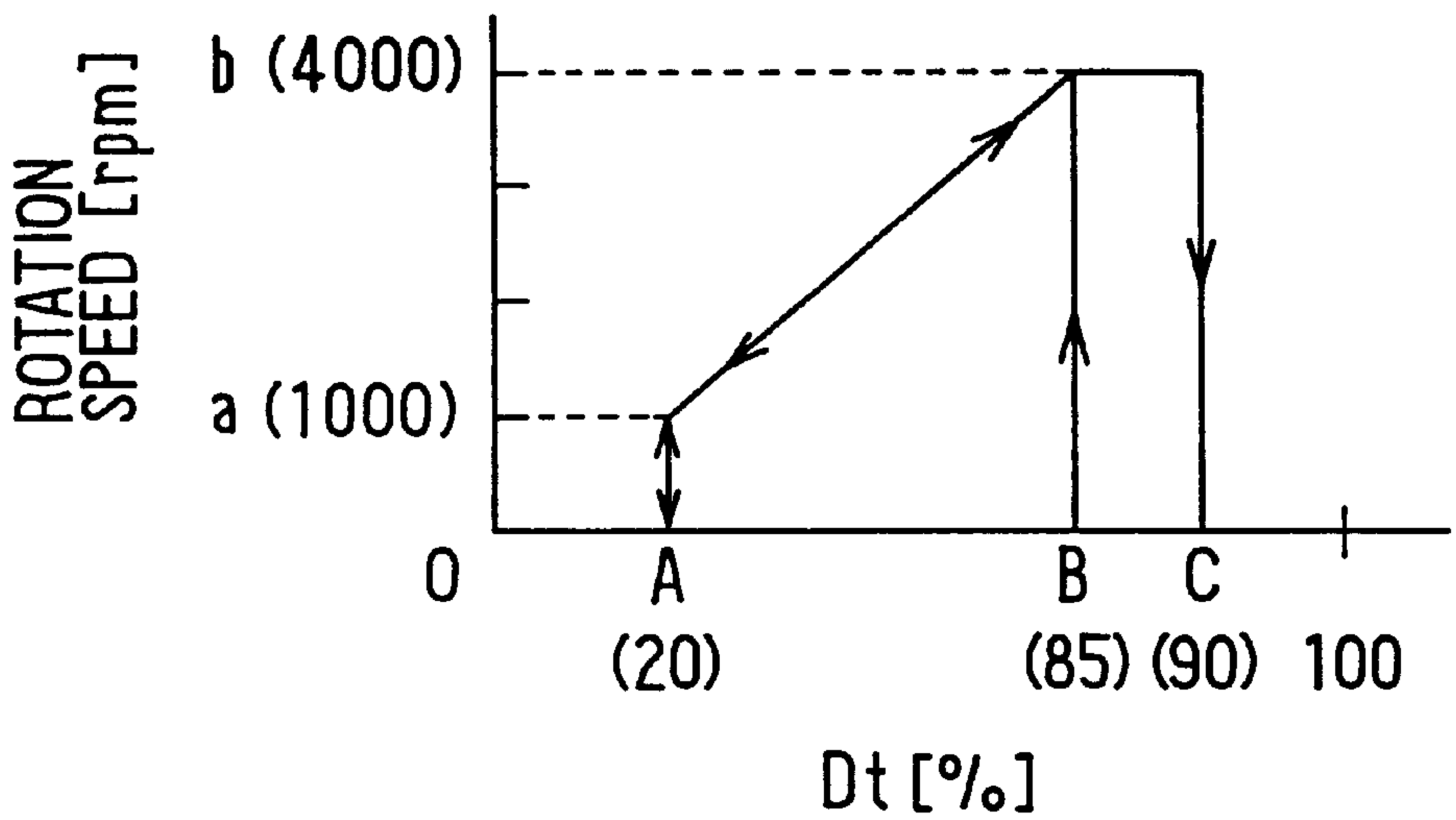

ROTATION SPEED [rpm]
b (4000)
a (1000)
0
A
(20)
B
(85)
C
(90)
100
Dt [%]

FIG. 5

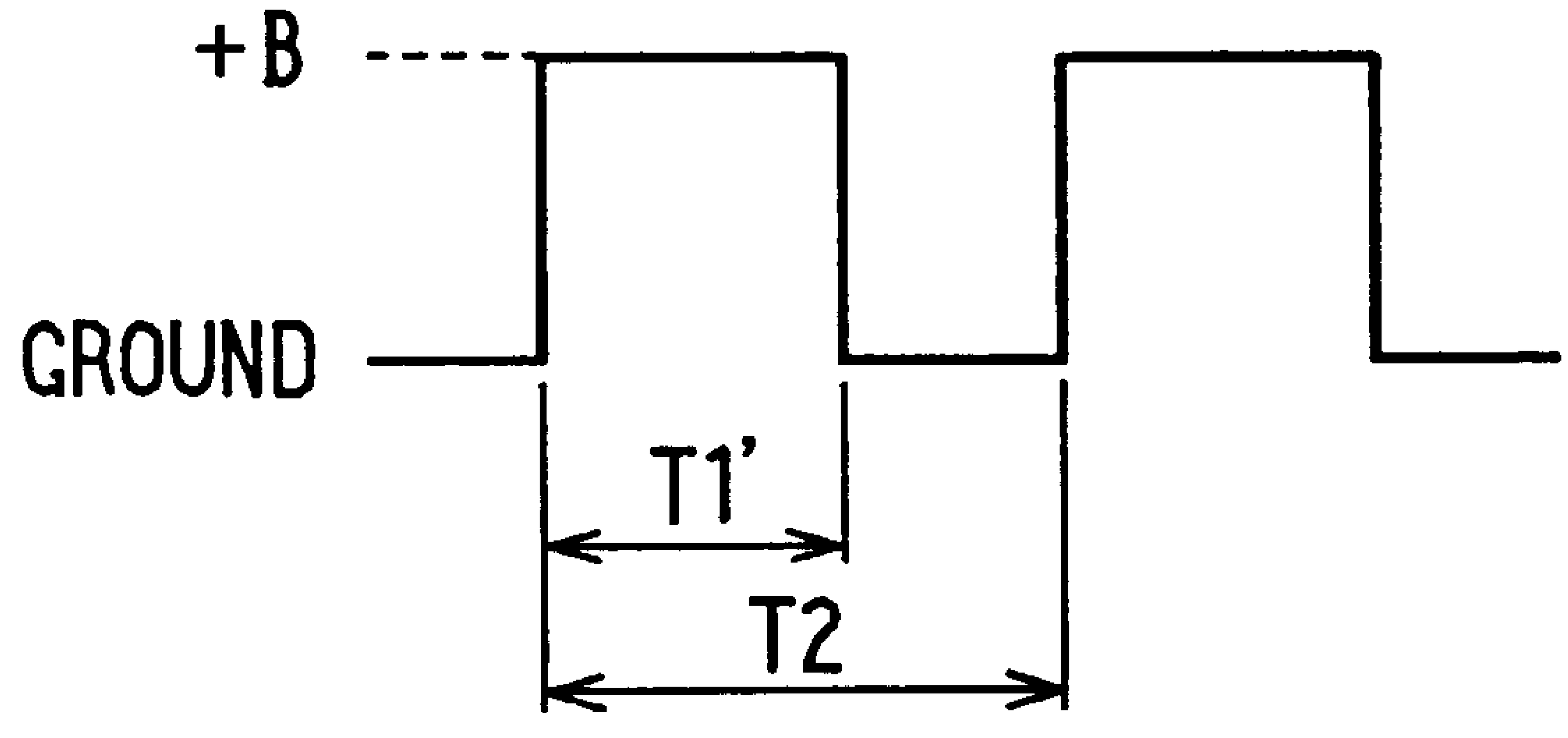

+B
GROUND
T1'
T2

FIG. 6
PRIOR ART

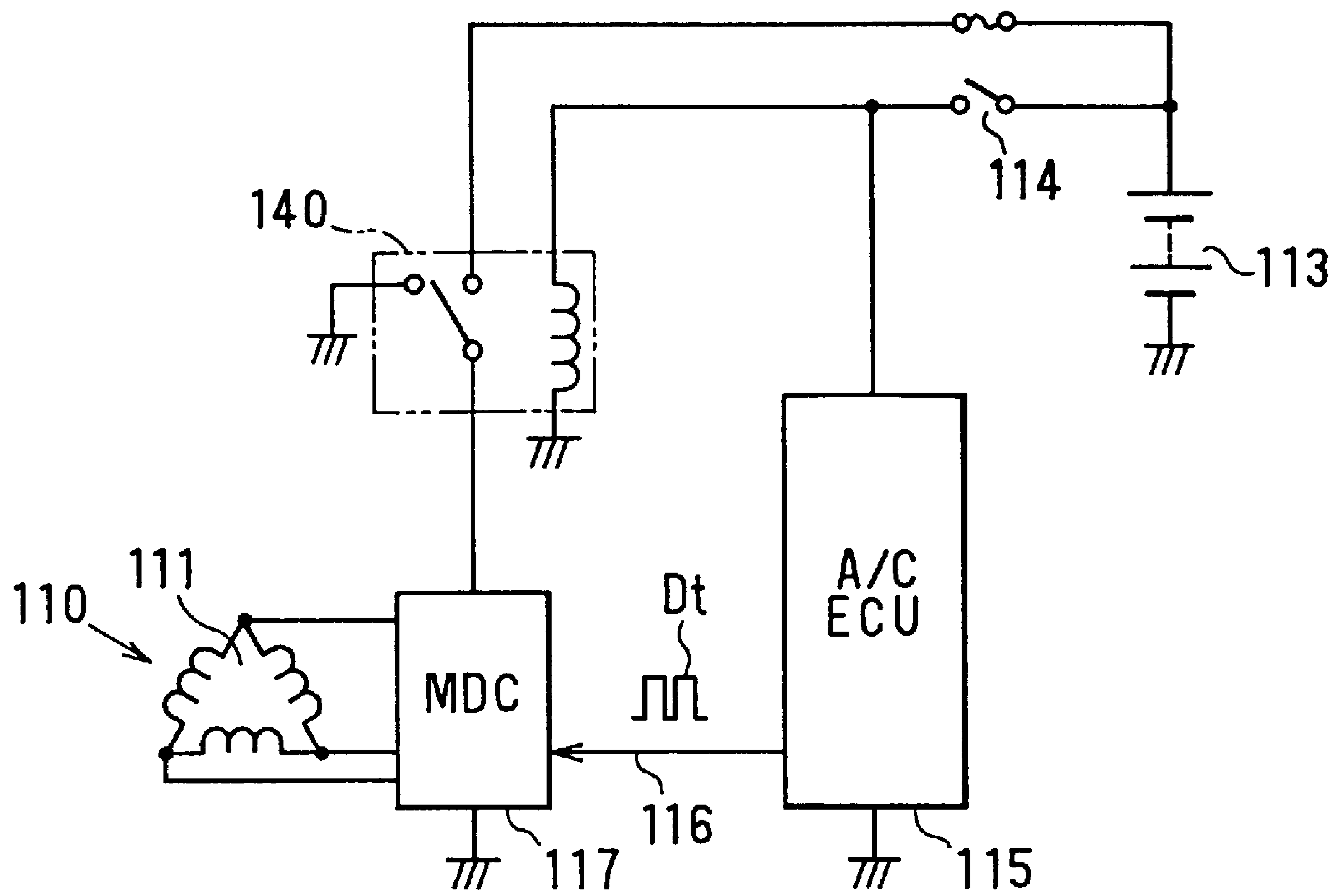
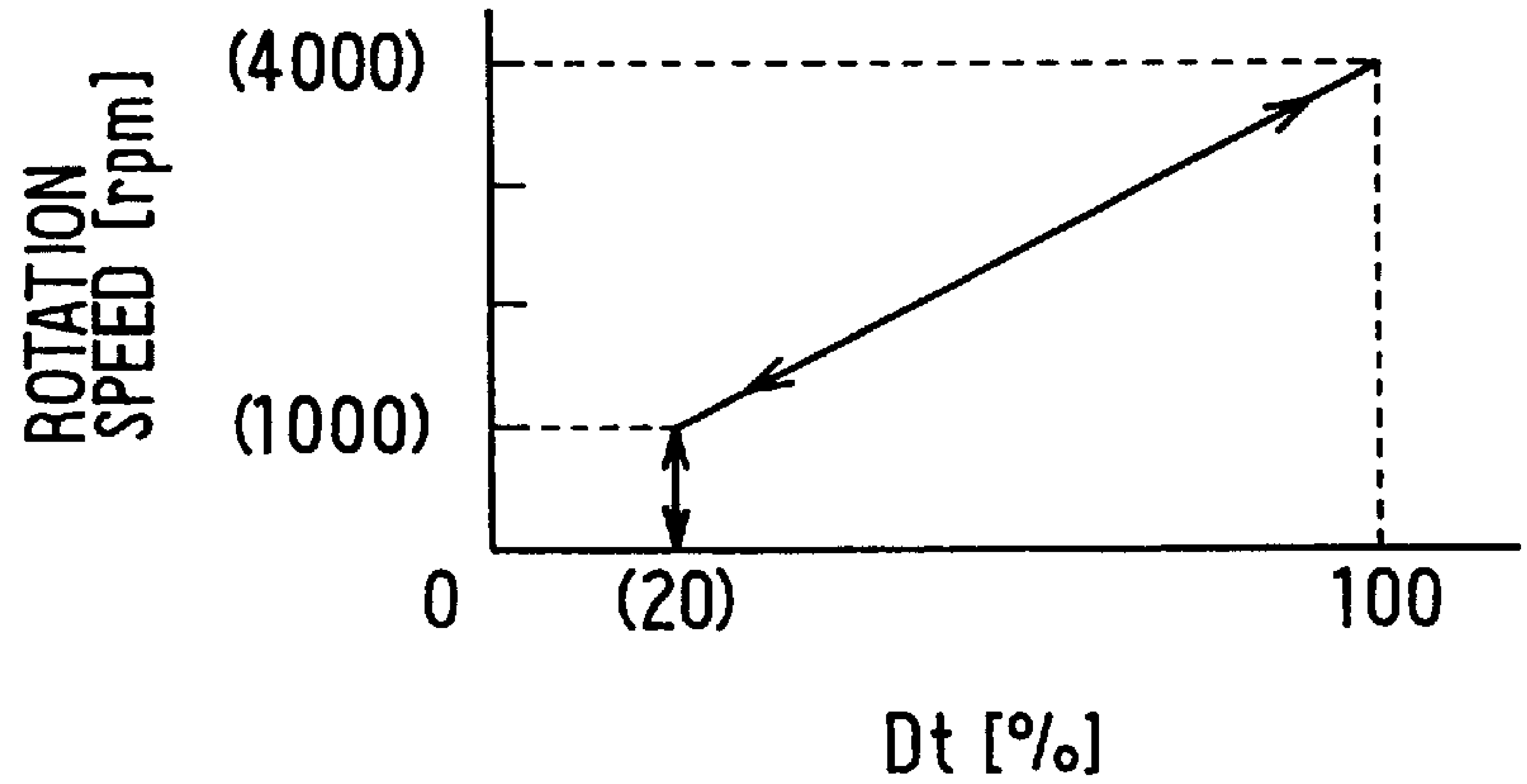



FIG. 7
PRIOR ART



# LOAD CONTROL SYSTEM FOR MOTOR

## CROSS-REFERENCE TO RELATED APPLICATION

This application is related to and claims priority from Japanese Patent Application No. Hei. 10-269965 filed on Sep. 24, 1998, the contents of which are hereby incorporated by reference.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a load control system for preventing an error operation of a driving unit when a signal input line of a driving circuit is short-circuited, more particularly relates to a load control system for a blower motor of a vehicle air conditioner.

2. Description of Related Art

In recent years, a motor without a commutator and a brush (hereinafter, referred to as "motor") is used as a blower motor of a vehicle air conditioner, and a rotation speed of the motor is controlled by performing a pulse-width modulation control (PWM control) relative to a driving signal of an inverter for controlling electrical power applied to an armature winding of the motor.

For example, in a vehicle air conditioner, an electrical relay **140** which is turned on when an ignition switch **114** of a vehicle engine turns on is disposed between a vehicle battery **113** and a motor driving circuit (MDC) **117** of a blower motor **110**, as shown in FIG. **6**. That is, electrical power is supplied from the vehicle battery **113** to the motor driving circuit **117** through the electrical relay **140**.

Further, as shown in FIG. **6**, an armature winding **111** of the blower motor **110** is delta-connected, and an air-conditioning control unit (A/C ECU) **115** is connected between the ignition switch **114** and the motor driving circuit **117**. The air-conditioning control unit **115** calculates a target rotation speed of the blower motor **110** and outputs a duty signal Dt. The duty signal Dt output from the air-conditioning control unit **115** is input into the motor driving circuit **117** through a signal input line **116**. In the conventional system, the rotation speed of the blower motor **110** is controlled by the motor driving circuit **117** to be increased in proportion to an increase of the duty signal percentage (ratio) Dt (%), as shown in FIG. **7**. Therefore, when the motor driving circuit **117** of the blower motor **110** or the air-conditioning control unit **115** has a trouble and full-load operation of the blower motor **110** is performed, the ignition switch **114** is turned off by a passenger, so that the electrical relay **140** is turned off and operation of the blower motor **110** can be stopped.

However, when the electrical relay **140** is not provided for reducing cost, the motor driving circuit **117** is directly connected to the vehicle battery **113**. In this case, when the signal input line **116** for inputting signal to the motor driving circuit **117** is short-circuited on a vehicle side (i.e., ground short-circuited), 100% of duty signal Dt is applied to the motor driving circuit **117**. As a result, the full-load operation of the blower motor **110** is continued even when the ignition switch **114** is turned off in this case, and over-discharge of the vehicle battery **113** may be caused.

## SUMMARY OF THE INVENTION

In view of the foregoing problems, it is an object of the present invention to provide a load control system for a driving unit, which can automatically prevent full-load operation of the driving unit due to short-circuit of a signal input line for inputting signal from a control circuit to a driving circuit, even when the driving circuit is directly connected to a power source.



According to the present invention, a load control system for a driving unit includes a driving circuit directly connected to an electrical power source to electrically control the driving unit, a control unit for generating a control signal for the driving unit, a signal input line through which the control signal from the control circuit is input to the driving circuit, and a determining unit for determining a short-circuited state of the signal input line. In the load control system, when the determining unit determines that the short-circuited state of the signal input line, the driving circuit stops operation of the driving unit based on an output signal from the determining unit. Thus, even when the signal input line is short-circuited when the driving circuit is directly connected to the power source, the determining unit determines the short-circuited state, and the driving unit is automatically stopped. As a result, over-discharging of the power source is prevented.

Preferably, the control signal from the control circuit is a duty signal in which a duty ratio becomes 100% when the signal input line is short-circuited, and the determining unit determines that the signal input line is short-circuited when the duty ratio is increased to a value proximate to 100%. Therefore, the short-circuited state of the signal input line is readily determined without using a special sensor, and the load control system protects the driving unit with a simple structure.

More preferably, the driving circuit controls the driving unit in such a manner that load applied to the driving unit is increased as the duty ratio of the duty signal increases, until the duty ratio is increased to a predetermined value lower than 100%, and the driving circuit stops operation of the driving unit when the duty ratio becomes more than the predetermined value. Therefore, both of operation control of the driving unit during a normal operation and an automatic stop of the driving unit at an abnormal operation can be accurately performed.

## BRIEF DESCRIPTION OF THE DRAWINGS

Additional objects and advantages of the present invention will be more readily apparent from the following detailed description of a preferred embodiment when taken together with the accompanying drawings, in which:

FIG. **1** is an electric wiring diagram showing a load control system according to a preferred embodiment of the present invention;

FIG. **2** is a timing chart with operation of a blower motor according to the embodiment;

FIG. **3** is a wave form chart of a duty signal according to the embodiment;

FIG. **4** is a graph of a motor output characteristic, showing the relationship between a rotation speed of the blower motor and a duty signal percentage Dt (%), according to the embodiment;

FIG. **5** is a wave form chart of a duty signal of a comparison example;

FIG. **6** is an electric wiring diagram showing a conventional load control system; and

FIG. **7** is a graph of a conventional motor output characteristic.

## DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described hereinafter with reference to FIGS. **1–5**. In the preferred embodiment, the present invention is applied to a control unit of a blower motor **10** for a vehicle air conditioner. The blower motor **10** is a motor without a commutator and a brush. As shown in FIG. **1**, the blower motor **10** includes a delta-communication armature coil **11**, a rotor (not shown) having a permanent magnetic for forming a rotating magnetic field, and a rotation position sensor **12** for detecting a rotation position of the rotor. For example, the rotation position sensor **12** is formed by a Hall element which detects a magnetic field change due to a rotation of a permanent magnet **12***a* connected to a rotation shaft of the rotor. In FIG. **1**, only a single rotation position sensor **12** is indicated. However, actually, three rotation position sensors **12** are disposed around the single permanent magnet **12***a* in a rotation direction of the permanent magnet **12***a* to have the same distance between adjacent rotation position sensors **12**. As shown in FIG. **2**, outputs U, V, W of the three rotation position detectors **12** are wave forms having a predetermined position difference relative to the rotation position of the rotor.

A vehicle battery **13** is provided so that electrical power is supplied to an electronic control unit (A/C ECU) **15** of the vehicle air conditioner through an ignition switch **14** of a vehicle engine. The electronic control unit **15** calculates a target air temperature TAO of air blown into a passenger compartment of the vehicle based on a temperature of inside air inside the passenger compartment, a temperature of outside air outside the passenger compartment, a sunlight amount entering into the passenger compartment and a setting temperature of the passenger compartment. Further, the electronic control unit **15** calculates a target rotation speed of a blower based on the calculated target air temperature TAO. The calculated target rotation speed of the blower is output as a duty signal Dt from the electronic control unit **15**, and is input into an input terminal **17**a of a motor driving circuit **17** through a signal input line **16**.

A duty signal percentage (duty signal ratio) Dt(%) is calculated based on a wave form of a duty signal shown in FIG. **3**. That is, the duty signal percentage Dt(%)=(T1/T2)× 100%. The relationship between the duty signal percentage Dt(%) and a rotation speed of the blower motor **10** is shown in FIG. **4**.

Next, a motor driving circuit **17** will be now described. An inverter **18** for controlling electrical power supplied to the armature coil **11** of the blower motor **18** forms a three-phase full-wave bridge circuit by using six field-effect transistors (FET) **18**a as switching elements. The duty signal Dt from the signal input line **16** is converted to an analog voltage in a duty-voltage conversion circuit **19**, and an analog voltage corresponding to the target rotation speed of the blower motor **10** is output from the duty-voltage conversion circuit **19**.

On the other hand, a frequency of output of the rotation position sensor **12** is converted to an analog voltage in a frequency-voltage conversion circuit **20**, and an analog voltage corresponding to an actual rotation speed of the blower motor **10** is output from the frequency-voltage conversion circuit **20**. Next, a pulse-width modulating control is performed in a pulse-width modulating circuit **21** based on outputs from both conversion circuits **19**, **20** so that the actual rotation speed of the blower motor **10** becomes equal to the target rotation speed, and an output pulse width is determined in the pulse-width modulating circuit **21**. Driving control signals for controlling the six field-effect transistors (FET) **18***a* of the inverter are output from a FET driving control circuit **22**, and the driving control signals are determined based on a rotor rotation position detected by the rotation position sensor **12** so that electrical control of the six field-effect transistors **18***a* is performed.

In the timing diagram of FIG. **2**, U(up-FET), U(low-FET), V(up-FET), V(low-FET), W(up-FET), W(low-FET) indicate driving control signals from the FET driving control circuit **22** for controlling the six field-effect transistors **18***a*. Here, U, V, W correspond to outputs U, V, W of the rotation position sensor **12**, and correspond to combinations U, V, W combining each pair of up and low field-effect transistors **18***a* of the inverter **18**.

A comparison circuit **23** (determining unit) determines whether or not output voltage from the duty-voltage conversion circuit **19** reaches to a predetermined level. Each field-effect transistor **18***a* is operated by an operation circuit **24** based on the theoretical product of the output from the pulse-width modulating circuit **21**, the output from the FET driving control circuit **22** and the output from the comparison circuit **23**. In FIG. **1**, only a single output line of the FET driving control circuit **22** is indicated relative to the operation circuit **24**. However, actually, six output lines corresponding to the six field-effect transistors **18***a* are provided in the FET driving control circuit **22**.

Electrical power supplied to each circuit **19**–**24** is controlled in a stand-by circuit **25** based on a duty signal Dt from the signal input line **16**. That is, according to the duty signal Dt from the signal input line **16**, electrical power is supplied to each circuit **19**–**24** when the blower motor **10** operates, and the supply of electrical power to each circuit **19**–**24** is stopped when operation of the blower motor **10** is stopped. Therefore, even when the motor driving circuit **17** is directly connected to the vehicle battery **13** without an electrical relay, electrical power consumption of each circuit **19**–**24** can be reduced.

Next, operation of the load control system according to the embodiment will be now described. Firstly, a normal operation will be now described. That is, in the normal operation, the signal input line **16** from the electronic control unit **15** to the motor driving circuit **17** does not have a trouble and is accurately connected to the input terminal **17***a* of the motor driving circuit **17**. During the normal operation, when the ignition switch **14** of the vehicle engine is turned on, electrical power is supplied to the electronic control unit **15** of the vehicle air conditioner so that the electronic control unit **15** is operated. With operation of the vehicle air conditioner, the electronic control unit **15** calculates the target rotation speed of the blower motor **10** based on a calculated target air temperature (TAO). The calculated target rotation speed of the blower motor **10** is changed to the duty signal Dt shown in FIG. **3**, and the duty signal Dt is input to the input terminal **17***a* of the motor driving circuit **17** through the signal input line **16**.

In the motor driving circuit **17**, the duty signal Dt is converted to an analog signal by the duty-voltage conversion circuit **19**, and the F-V conversion circuit **20** outputs an analog signal corresponding to an actual motor rotation speed. Based on the output signals from both conversion circuits **18**, **19**, a pulse width signal is output from the pulse-width modulating circuit **21** to the operation circuit **24**. The theoretical product of the output pulse width from the pulse-width modulating circuit **21** and the output control signal from the FET driving control circuit **22** is calculated in the operation circuit **24**, and each power-supplying time of the field-effect transistors **18***a* of the inverter **18** is controlled by an operation circuit **24**, thereby controlling the rotation speed of the blower motor **10**.

In the embodiment of the present invention, as shown in FIG. **4**, until the duty signal percentage Dt(%) is increased to a first predetermined value A (e.g., 20%) from zero, the operation of the blower motor **10** is stopped. After the duty signal percentage Dt(%) is increased to the first predetermined value A, the blower motor **10** is operated with a first predetermined rotation speed "a" (e.g., 1000 rpm). Thereafter, when the duty signal percentage Dt(%) is increased to be larger the first predetermined value A, the rotation speed of the blower motor **10** is increased in proportion to an increase of the duty signal percentage Dt(%). When the duty signal percentage Dt(%) is increased to a second predetermined value B (e.g., 85%) lower than 100% and proximate to 100%, the rotation speed of the blower motor **10** is increased to a full-load rotation speed "b" (e.g., 4000 rpm), and the blower motor is operated in a full-load operation state. The full-load operation state of the blower motor **10** is continued when the duty signal percentage Dt(%) is in a range between the second predetermined value B and a third predetermined value C (e.g., 90%) slightly larger than the second predetermined value B.

Until the duty signal percentage Dt(%) is increased to the third predetermined value C (e.g., 90%), it is determined that the signal input line **16** is in normal, and no signal is output from the comparison circuit **23**. When the duty signal percentage Dt(%) is larger than the third predetermined value C (e.g., 90%), it is determined that the signal input line **16** has a trouble such as a ground short-circuit based on an increase of the output voltage from duty-voltage conversion circuit **19**, and a signal is output from the comparison circuit **23**. According to the output signal from the comparison circuit **23**, all of the field-effect transistors **18***a* of the inverter **18** are compulsorily turned off, and the operation of the blower motor **10** is stopped. In this case, the motor driving circuit **17** is directly connected to the vehicle battery **13**. Therefore, when the signal input line **16** toward the motor driving circuit **17** is ground short-circuited, the duty signal ratio of 100% may be applied to the motor driving circuit **17**. However, according to the embodiment of the present invention, the comparison circuit **23** determines that the duty signal percentage Dy(%) is larger than the third predetermined value C (e.g., 90%), and the operation of the blower motor **10** can be automatically stopped. As a result, it can prevent the blower motor **10** from performing the full-load operation state in a long time due to the ground short-circuit of the signal input line **16**, thereby preventing over-discharging of the vehicle battery **13**.

In the above-described embodiment, as shown in FIG. **3**, the duty signal percentage D(%) is calculated from a time **T1** of a low level (e.g., ground voltage). As shown in FIG. **5**, in a case where the duty signal percentage D(%) is calculated from a time **T1**' of a high level (e.g., +B position battery voltage) by using T1'/T2×100(%), when the signal input line **16** becomes in an opened state, the duty signal percentage Dt(%) applied to the input terminal **17***a* of the motor driving circuit **17** becomes 100%, and the blower motor **10** is operated with the full-load operation. However, the opened state of the signal input line **16** is generally readily caused as compared with the ground short-circuited state. Therefore, actually, the duty signal percentage Dt(%) calculated from FIG. **3** is more preferable than that from FIG. **5**.

Although the present invention has been fully described in connection with the preferred embodiment thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications will become apparent to those skilled in the art.

For example, in the above-described embodiment, the structure and the operation of the motor driving circuit **17** are explained from the block diagram of FIG. **1**. However, the function of the motor driving circuit **17** is obtained by digital control of a micro-computer. Further, in the above-described embodiment, the present invention is applied to the blower motor without providing a commutator and a brush. However, the present invention may be applied to the other type motor, or the other electrical load except for the motor.



Such changes and modifications are to be understood as being within the scope of the present invention as defined by the appended claims.

What is claimed is:

**1**. A load control system for a driving unit, comprising:

a driving circuit for electrically controlling said driving unit, said driving circuit being directly connected to an electrical power source;

a control circuit for generating a control signal for said driving unit;

a signal input line through which the control signal from said control circuit is input to said driving circuit; and

a determining unit for determining a short-circuited state of said signal input line, wherein:

said driving circuit stops operation of said driving unit based on an output signal from said determining unit when the determining unit determines that a short-circuited state of the signal input line exists;

the control signal from said control circuit is a duty signal in which a duty ratio becomes 100% when said signal input line is short-circuited;

said determining unit determines the short-circuited state of the signal input line when the duty ratio is increased to a value proximate to 100%;

said driving circuit controls said driving unit in such a manner that load applied to said driving unit is increased as the duty ratio of the duty signal of said control circuit increase, until the duty ratio is increased to a predetermined value lower than 100%;

said driving circuit stops operation of said driving unit when the duty ratio becomes more than the predetermined value; and

said determining unit determines the short-circuited state of the signal input line when the duty ratio becomes more than the predetermined value.

**2**. The load control system according to claim **1**, wherein:

said driving unit performs full-load operation when said signal input line is short-circuited; and

the full-load operation is stopped by said driving unit when said determining unit determines the short-circuited state of said signal input line.

**3**. The load control system according to claim **1**, wherein the short-circuited state is a ground-side shorted state.

**4**. A driving-unit control apparatus comprising:

a driving unit driven electrically;

a driving circuit for electrically controlling said driving unit, said driving circuit being directly connected to an electrical power source;

a control circuit for generating a control signal for said driving unit;

a signal input line through which the control signal from said control circuit is input to said driving circuit; and

a determining unit for determining a short-circuited state of said signal input line, wherein:

said driving unit performs full-load operation when said signal input line is ground short-circuited;

said driving circuit stops the full-load operation of said driving unit when said determining unit determines the short-circuited state of said signal input line;

the control signal from said control circuit is a duty signal in which a duty ratio becomes 100% when said signal input line is ground short-circuited;

said determining unit determines the short-circuited state of the signal input line when the duty ratio is increased to a value proximate to 100%;

said driving unit is a motor having a rotor made from a permanent magnet and a delta-connection armature core;

said driving circuit controls operation of said motor by controlling an electrical power supplying to said armature coil of said motor;

said driving circuit controls said motor in such a manner that a rotation speed of said motor is increased as the



duty ratio of the duty signal of said control circuit increase, until the duty ratio is increased to a predetermined value lower than 100%; and

said driving circuit stops operation of said motor when the duty ratio becomes more than the predetermined value.

**5**. The driving-unit control apparatus according to claim **7**, wherein:

said motor is for operating a blower;

said control circuit calculates a target rotation speed of said motor; and

said control circuit generates the duty signal in such a manner that the duty ratio of the duty signal is increased in accordance with an increase of the target rotation speed.

* * * * *